CLAIMS

The invention claimed is:

1. A method of forming a metallic material on a silicon-comprising substrate comprising:

providing a substrate having a silicon-comprising surface; and

forming a layer comprising metallic glass over the silicon-comprising surface.

2. The method of claim 1 wherein the metallic material is a coating.

3. The method of claim 1 further comprising converting the metallic glass into a hardened layer comprising a nanocomposite microstructure.

4. The method of claim 3 wherein the nanocomposite microstructure has a grain size of from about 75 nm to about 125 nm.

5. The method of claim 3 wherein the layer comprises an initial hardness of at least about 9.2 GPa prior to the converting and wherein the hardened layer has an increased hardness relative to the initial hardness.

6. The method of claim 1 wherein the silicon-comprising surface comprises silicon oxide.

7. The method of claim 1 wherein the silicon-comprising surface comprises silicon dioxide.

8. The method of claim 1 wherein the silicon-comprising surface comprises monocrystalline silicon.

9. The method of claim 1 wherein the metallic glass is formed from a material comprising an Fe-based alloy containing at least one of P, C, B, and Si, the alloy having a total elemental composition consisting essentially of fewer than eleven elements.

10. The method of claim 9 wherein the Fe-based alloy contains at least 55% Fe, by weight.

11. A method of metallizing a surface comprising:

providing a substrate having a surface, at least part of the surface comprising silicon; and

depositing a metallic material over at least a portion of the surface, the metallic material comprising Fe and at least one member of the group consisting of B, Si, P and C.

12. The method of claim 11 wherein the metallic material comprises B, Si and C.

13. The method of claim 11 wherein the metallic material comprises metallic glass after the depositing.

14. The method of claim 11 wherein the metallic material comprises metallic glass after the depositing , and further comprising converting at least a portion of the metallic glass to a crystalline material having a nanocrystalline grain size.

15. A method of protecting a silicon-comprising substrate comprising:

providing a silicon-comprising substrate within a deposition chamber;

providing a deposition target within the deposition chamber; and

depositing material from the deposition target over at least a portion of the silicon-comprising substrate to form a protective layer comprising metallic glass.

16. The method of claim 15 wherein the deposition chamber is a laser deposition chamber and wherein the depositing comprises laser deposition.

17. The method of claim 15 wherein the depositing occurs at a rate of about 10 Å per second.

18. The method of claim 15 wherein the protective layer comprises a thickness of from about 10 Å to about 3 μm.

19. The method of claim 18 wherein the protective layer comprises a thickness of from about 0.5 μm to about 1.5 μm.

20. The method of claim 15 wherein the silicon-comprising substrate is patterned prior to the providing the silicon-comprising substrate.

21. The method of claim 15 wherein target comprises a composition selected form the group consisting of $Fe_{63}Mo_2Si_1$, $Fe_{63}Cr_8Mo_2$, $Fe_{63}Mo_2Al_4$, $(Fe_{0.8}Cr_{0.2})_{81}B_{17}W_2$, $(Fe_{0.8}Mo_{0.2})_{83}B_{17}$, $Fe_{63}B_{17}Si_1$, $Fe_{63}Cr_8Mo_2C_5$, $Fe_{63}Mo_2C_5$, $Fe_{80}Mo_{20}$, $Fe_{63}Cr_8Mo_2B_{17}$, $Fe_{83}B_{17}$, $Fe_{63}B_{17}Si_5$, $Fe_{63}B_{17}C_2$, $Fe_{63}B_{17}C_3Si_3$, $(Fe_{0.8}Cr_{0.2})_{79}B_{17}W_2C_2$, $Fe_{63}B_{17}C_3Si_5$, $Fe_{63}B_{17}C_2W_2$, $Fe_{63}B_{17}C_8$, $Fe_{63}B_{17}C_5$, $(Fe_{0.8}Cr_{0.2})_{78}Mo_2W_2B_{12}C_5Si_1$, $Fe_{63}B_{17}C_5W_5$, $Fe_{63}B_{17}C_5Si_5$, $(Fe_{0.8}Cr_{0.2})_{76}Mo_2W_2B_{14}C_5Si_1$, $(Fe_{0.8}Cr_{0.2})_{73}Mo_2W_2B_{16}C_4Si_1Mn_2$, $Fe_{63}Cr_8Mo_2B_{17}C_5$, $(Fe_{0.8}Cr_{0.2})_{75}Mo_2B_{17}C_5Si_1$, $Fe_{63}Cr_8Mo_2B_{17}C_5Si_1Al_4$, $(Fe_{0.8}Cr_{0.2})_{75}W_2B_{17}C_5Si_1$, $Fe_{63}B_{17}C_5Si_1$, $(Fe_{0.8}Cr_{0.2})_{73}Mo_2W_2B_{17}C_5Si_1$, $(Fe_{0.8}Cr_{0.2})_{72}Mo_2W_2B_{17}C_5Si_1Gd_1$, $(Fe_{0.8}Cr_{0.2})_{71}Mo_2W_2B_{17}C_5Si_1Gd_2$, and $(Fe_{0.8}Cr_{0.2})_{74}Mo_2W_2B_{17}C_4Si_1$.

22. The method of claim 14 further comprising converting at least some of the metallic glass to a crystalline material having a nanocrystalline grain size.

23. The method of claim 22 wherein the converting comprises heating at least a portion of the protective layer to a temperature of about 700°C.

24. A metal coated substrate comprising:

a substrate having a silicon-comprising surface; and

a metallic coating adhered to at least a portion of the silicon-comprising surface, the metallic coating comprising at least 55% Fe, and from 0% to about 2% C by weight.

25. The metal coated substrate of claim 24 wherein the metallic coating further comprises at least one member of the group consisting of C, P, Si, and B.

26. The metal coated substrate of claim 24 wherein the metallic coating comprises a metallic material selected from the group consisting of $Fe_{63}Mo_2Si_1$, $Fe_{63}Cr_8Mo_2$, $Fe_{63}Mo_2Al_4$, $(Fe_{0.8}Cr_{0.2})_{81}B_{17}W_2$, $(Fe_{0.8}Mo_{0.2})_{83}B_{17}$, $Fe_{63}B_{17}Si_1$, $Fe_{63}Cr_8Mo_2C_5$, $Fe_{63}Mo_2C_5$, $Fe_{80}Mo_{20}$, $Fe_{63}Cr_8Mo_2B_{17}$, $Fe_{83}B_{17}$, $Fe_{63}B_{17}Si_5$, $Fe_{63}B_{17}C_2$, $Fe_{63}B_{17}C_3Si_3$, $(Fe_{0.8}Cr_{0.2})_{79}B_{17}W_2C_2$, $Fe_{63}B_{17}C_3Si_5$, $Fe_{63}B_{17}C_2W_2$, $Fe_{63}B_{17}C_8$, $Fe_{63}B_{17}C_5$, $(Fe_{0.8}Cr_{0.2})_{78}Mo_2W_2B_{12}C_5Si_1$, $Fe_{63}B_{17}C_5W_5$, $Fe_{63}B_{17}C_5Si_5$, $(Fe_{0.8}Cr_{0.2})_{76}Mo_2W_2B_{14}C_5Si_1$, $(Fe_{0.8}Cr_{0.2})_{73}Mo_2W_2B_{16}C_4Si_1Mn_2$, $Fe_{63}Cr_8Mo_2B_{17}C_5$, $(Fe_{0.8}Cr_{0.2})_{75}Mo_2B_{17}C_5Si_1$, $Fe_{63}Cr_8Mo_2B_{17}C_5Si_1Al_4$, $(Fe_{0.8}Cr_{0.2})_{75}W_2B_{17}C_5Si_1$, $Fe_{63}B_{17}C_5Si_1$, $(Fe_{0.8}Cr_{0.2})_{73}Mo_2W_2B_{17}C_5Si_1$, $(Fe_{0.8}Cr_{0.2})_{72}Mo_2W_2B_{17}C_5Si_1Gd_1$, $(Fe_{0.8}Cr_{0.2})_{71}Mo_2W_2B_{17}C_5Si_1Gd_2$, and $(Fe_{0.8}Cr_{0.2})_{74}Mo_2W_2B_{17}C_4Si_1$.

27. The metal-coated substrate of claim 24 wherein the silicon-comprising surface comprises a member of the group consisting of monocrystalline silicon, polysilicon, silicon oxide and silicon dioxide.

28. A silicon-comprising structure comprising:

a substrate comprising silicon; and

a metallic layer over the substrate, the metallic layer comprising less than or equal to about 2 weight percent carbon and having a hardness of at least about 9.2 GPa.

29. The structure of claim 28 wherein the metallic layer comprises metallic glass.

30. The structure of claim 28 wherein the metallic layer comprises nanocrystalline microstructure.

31. The structure of claim 28 wherein the substrate comprises a silicon surface and wherein the metallic layer is deposited onto the silicon surface.

32. A protected silicon surface comprising

a layer of metal material over a silicon surface, the layer of metal material comprising:

at least 55% Fe; and

a hardness of at least about 9.2 GPa.

33. The protected silicon surface of claim 32 wherein the silicon surface is planar.

34. The protected silicon surface of claim 32 wherein the silicon surface comprises silicon oxide.

35. The protected silicon surface of claim 32 wherein the silicon surface is non-planar.

36. The protected silicon surface of claim 32 wherein the silicon surface is a patterned surface.

37. The protected silicon surface of claim 32 wherein the metal material comprises metallic glass.

38. The protected silicon surface of claim 32 wherein the metal material comprises a nanocrystalline grain size.

39. The protected silicon surface of claim 32 layer of metal material comprises a thickness of from about 10 Å to about 3 μm.